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GLASSES FOR INDICATING DUST CONTAMINATION

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Compositions are worked out for magnesium-silicon-phosphate glasses in which neutron irradiation produces the radioactive isotope of phosphorus P^{32} with half-life 14.22 days. A technology for obtaining microspheres from the synthesized glasses is presented. It is recommended that the powder made from the glass developed be used as indicators of solid aerosols behavior and efficiency of filtering apparatus.

Key words: glass, microspheres, isotopes, irradiation, radioactivity, solid aerosols, dust.

The most effective indicator of dust contamination is radioactive glass dust, which can be used successfully for indicating dust contamination, studying the behavior of solid aerosols, detecting hazardous dust in uncontaminated rooms and determining the amount of dust settled on and passing through a filter. The active particles can be obtained either by deposition of particles of a radioactive isotope from a solution onto a surface or by irradiating dust in a nuclear reactor.

Silicate glass powders activated by radioactive oxides are widely used for such purposes. Glass dust melts at high temperatures in the presence of radioactive oxides, which are sorbed on the surface of the particles. Radioactive dust does not always adhere tightly to glass and can separate during work, thereby contaminating instruments and controlling apparatus.

Glass dust activated by depositing on its surface a radioactive isotope from a solution can be used only for measuring the adhesion forces in the ambient air, since in a liquid medium radioactive isotopes pass into solution, making it impossible to determine the number of particles by a radiometric method.

The most promising materials for such purposes are phosphate glasses containing large amounts phosphate anhydride. The β-emitting radioactive isotope P^{32} with half-life 14.22 days is formed in these glasses under neutron irradiation. This short-lived isotope makes it possible to detect efficiently dust contaminations which are of no danger to maintenance workers, since the irradiation of the glass powder is conducted at the last stage of its preparation for use in an experiment.

The glass used to study the behavior of solid aerosols must be low-melting, so that microspheres would fuse from the glass dust at temperatures not exceeding 1000°C. The glass must not contain oxides which under neutron irradiation give characteristic isotopes, so that the radiation from the radioactive phosphorus would not be contaminated.

Aluminum and magnesium oxides are examples of oxides that modify the structure of a glassy matrix and do not engender radioactive isotopes. Long-lived isotopes are formed when other oxides are irradiated (Table 1).

Glasses in the ternary aluminum-magnesium phosphate system are quite hard and their melting temperatures lie in the range 1470 – 1500°C.

We chose the ternary system P_2O_5–MgO–SiO_2 and synthesized a series of glasses.

Magnesium-silicon-phosphate glasses are low-melting. Their melting temperature does not exceed 1350°C, and their fritting temperature is 800 – 1000°C. The synthesized glasses are chemically stable and do not crystallize during secondary heat-treatment.

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TABLE 1. Half-Life of Some Isotopes

Cation	Isotopes							
	Na^{22}	Na^{24}	K^{42}	Ca^{45}	Co^{60}	Zn^{65}	Sr^{89}	Zr^{95}
Half-life	2.58 yr	14.90 h	12.52 h	164 days	5.24 yr	245 days	50.5 days	65 days
Type of radiation	β^+, γ	β^-, γ	β^-, γ	β^-	β^-, γ	β^+	β^-, γ	β^-, γ

The melting was conducted in quartz crucibles. The glasses are well reproduced under different melting conditions in a gas furnace and a laboratory electric furnace with silicon carbide heaters; this is confirmed by a full chemical analysis of the synthesized compositions.

The fined, uniform glasses were produced in the form of pellets by casting into water.

The dried pellets were comminuted in a ball mill with uralite milling bodies to milling thickness ≤ 40 ìm. The glass powder fraction < 20 ìm was sieved out.

Next, the glass dust was mixed with comminuted alumina with particle size ≤ 20 ìm.

The mixture obtained was fired in an electric muffle furnace at temperature 800 – 950°C and layer thickness ≤ 10 mm in 30 min. The glass particles were fritted and transformed into microspheres.

After cooling the mixture was placed in water, from which the glass dust is separated from the alumina by settling.

The glass prepared in this manner was irradiated in a neutron flux 0.5×10^{12} neutrons in 3 h, creating activity of the order of 3.7 GBq/g glass.

A significant concentration of the radioactive isotope of phosphorus P^{32} with half-life 14.22 days is created in the glass.

Gamma-spectral analysis of the neutron-activated glasses showed that they do not contain unaccounted for impurities in amounts leading to the formation in the glass of radioactive contaminants during neutron activation which are significant compared with the beta-activity of the induced radiophosphorus, whose level corresponds to the computed amount.

The formation in the glass of a short-lived β-emitting isotope makes it possible to use it as an indicator of the behavior of solid aerosols, dust migration and adhesion of powders and dust under experimental and industrial conditions. Radioactive glass dust is very effective in studying the operation of filtering setups; it can be used to make a quantitative determination of the particles passing through the filters and settling on them.

The use of radioactive indication for detection and quantitative determination of dust contamination makes this method highly sensitive, and it is possible to detect dust in micro quantities, inaccessible for study by other known methods — weighing, luminescence and so forth.

Our magnesium-silicon-phosphate glass compositions are recommended for use in scientific and industrial studies of the behavior of solid aerosols in different technological processes.